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Prone to Success: The Effects of Prone on Handwriting Legibility

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Prone to Success: The Effects of Prone on Handwriting Legibility

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Abstract: This study was conducted to answer the question: “Does writing in prone result in more legible handwriting?” due to the prevalence of the prone position used in occupational therapy as a handwriting intervention and the lack of data supporting it. The study participants included 43 kindergarteners divided into an intervention group and control group based on convenience through classroom enrollment. The intervention or prone group did at least three prone activities a week for three weeks and the control group followed their normal handwriting curriculum. A pre-posttest of each group was performed using the *Handwriting Without Tears Screener of Handwriting Proficiency*. Based on the pre-posttest paired t-tests for each group, both groups had a significant improvement in memory, and just the prone group displayed a significant increase in placement, sentence, and total scores. The results of the prone minus control pre-post difference independent t-test showed that the prone group had a significant improvement in placement, sentence, and total scores. Despite the results displaying a positive relationship between writing in prone and legibility, these results cannot be generalized to a larger population based on the studies limitations in its evaluations, intervention, and participant populations.

Keywords and phrases: prone, dysgraphia, handwriting intervention, writing difficulties, honors thesis

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INTRODUCTION

An overwhelming number of elementary aged students face handwriting difficulties. Occupational therapists address handwriting difficulties using a variety of methods. One way occupational therapists intervene when it comes to handwriting difficulties is by having children write while lying prone, or on their stomachs. While many occupational therapists use this method there has been little research done on the effectiveness of having children write in a prone position. My study seeks to address the problem that little is known about if writing in the prone position will improve a student's handwriting skills. The purpose of this research study is to determine if writing in the prone position improves an elementary school student's handwriting. This study asks, does lying in a prone position (on one's stomach using their elbows for stability) result in

more legible handwriting? Based on my research I hypothesize that the results of my study will show that writing in prone leads to more legible handwriting.

Writing requires a complex set of motor and information processing skills. As a result, many difficulties can arise to hinder a child's handwriting abilities. Up to 27% of school aged children have been reported to suffer from writing difficulties (Van Hartingsveldt et al., 2011). Children with writing difficulties are often labeled as having dysgraphia. Dysgraphia covers a variety of issues children have with writing, "including problems with letter formation/legibility, letter spacing, spelling, fine motor coordination, rate of writing, grammar, and composition" (Chung et al., 2020). Poor or illegible handwriting can cause issues for students in the classroom, such as teachers interpreting a student's written response as incorrect or as a failure to follow directions. Overall, "when students find it difficult to write legibly, it affects their overall achievement in school and hence weakens their educational progress" (Oche, 2014). Handwriting difficulties can also switch a student's concentration off the subject matter or instructor in order to focus on correctly forming letters. These competing attention demands can negatively affect the coherency and complexity of the students' work (Dinehart, 2014). Handwriting problems also affect the speed at which a student can produce work. Children with writing difficulties often produce less text due to a higher percentage of time spent pausing between pencil strokes (Scordella et al., 2015). A child's ability to produce legible handwriting is important for expressing, communicating, and recording ideas. It is also necessary for educational development and achievement, considering 30-60% of class time is predominantly spent doing activities that involve handwriting (Chang & Yu, 2013).

Chang and Yu (2013) discuss how the most common occupational therapy referrals in elementary school are for handwriting difficulties. The influence occupational therapists have on correcting handwriting problems can be seen through a study between students that received occupational therapy focused on handwriting and those that received no occupational therapy. This study showed that, on average, legibility increased by 14.2% in the students who received services and by 5.8% in the students who did not receive services (Parush et al., 2010). Occupational therapists address handwriting difficulties through a number of methods. These methods include repeated fine motor task exercises, such as continuously touching the thumb to the tip of each finger (Parush et al., 2010), using different sized writing utensils (Kadam et al., 2019), and many more due to the sheer number of students that face difficulties with handwriting.

Handwriting difficulties often result from a lack of fine motor skills; however, fine motor skill development is only possible if core strength and stability is present. Before being able to effectively control their arm movement, a child must have proper muscle tone and stability in their trunk. A child's trunk should serve as their strong base to allow their arms and hands to make the precise and coordinated movements that are needed to execute tasks that require fine motor skills such as drawing and writing (Hanscom, 2016). Writing requires more than fine motor skills because the formation of letters requires ongoing motor and directionality, which relates to elements of spatial relationships (Parush et al., 2010). Not only do prone activities strengthen head, neck, and trunk muscles, but lying in prone also helps with spatial recognition. By having children lay down prone, using their elbows to prop them up, the shoulders, arms and hands receive stimuli about the position and movement of their body and tactile input, which

helps children learn where their body is in space. In a study done by Parush S, et al. (2010) perceptual-motor components are found to relate to handwriting ability. This study also found that spatial relationships relate to overall legibility. This relationship was evident in both writing conditions of copying and dictation.

Together, these sources work together to identify the problem my study hopes to address, that of the overwhelming number of children with handwriting difficulties. The results of the studies displayed the connection between visual–spatial skills and both general motor coordination and handwriting, as well as overall legibility and spatial organization. Another study elaborated how children with dysgraphic characteristics have an increased number of directional changes in velocity and an increased pause time per stroke (Chang & Yu, 2013). All these results can be used to demonstrate the broader relationship of fine motor skills to handwriting. From these articles, there is a clear need for more research into ways of improving handwriting. This need, combined with the benefits of writing in prone, worked together to create the hypothesis that lying in a prone position (on one's stomach using their elbows for stability) will result in more legible handwriting.

LITERATURE REVIEW

Skills Involved in Handwriting

While handwriting may seem easy for those without handwriting difficulties, it is a complex activity requiring a vast set of skills. "Impairment in even one facet of the writing process can impair an individual's ability to generate an age-appropriate product" (Chung, et. all, 2020). While there are numerous factors proven to influence handwriting

and more theorized to affect handwriting, only those related to lying in prone are presently discussed.

Fine Motor Skills. Fine motor skills are a key variable in handwriting development, as they have been linked to commonly made writing errors (Dinehart, 2015). Poor fine motor control, such as the lack of coordination of muscle contractions and irregularities in stroke speed and force may lead to laborious or even illegible handwriting (Chang & Yu, 2013). Dinehart displays how fine motor skills can predict handwriting skills, even before children can produce letters through evaluating other fine motor tasks of preschoolers and following those students all the way through second grade, showing fine motor skills not only predict handwriting ability but achievement as well (2015).

Proximal Stability. Proximal stability encompasses core strength and stability. The core is the body's strong base for motor functions. That is why in order to develop distal mobility, proximal stability or core strength and mobility is necessary. Distal mobility includes extremity functions such as fine motor skills, a necessary skill for handwriting. Due to this, proximal stability and distal mobility are necessary, prerequisite foundations for handwriting. In addition, a 2007 study showed that proximal stability and distal mobility effect handwriting function. The same study also showed that an occupational therapist's knowledge of the type of proximal and distal muscle activity used during handwriting can aid in providing personalized handwriting intervention (Naider-Steinhart, & Katz-Leurer).

Visual Spatial Skills and Perception. Studies have shown that children with dysfunctional handwriting also have impaired visual perception. In 2006, a study showed

how this connection between visual perception and handwriting difficulties is present even in "typically developing" children (Denton, et. al, 2006). In a 2015 study, visual–spatial skills were shown to be involved in handwriting as much as general motor coordination (Scordella, et. al). Problems with visual perception affects handwriting as it greatly impairs the spacing of letters, which has been shown to result in issues with spontaneous writing and copying text (Chung, et. al, 2020).

Visual Motor Integration. Visual motor integration, which is defined as the ability to "look at a form and copy it accurately" has been shown to have a strong relation to handwriting, with a study by Denton, et. al, showing that a deficit in visual motor integration is present with dysfunctional handwriting (Denton, et. al, 2006). To measure visual motor integration, the Developmental Test of Visual Motor Integration (VMI), was developed and has been shown to be the best predictor of handwriting legibility, which links the two skills. In a study done by Cornhill and Case-Smith students with poor handwriting scored significantly lower on the VMI than students with good handwriting. Handwriting requires visual motor integration to know what letter to write, visualize the letter form and shape, and be able to manipulate a writing tool to produce the letter (Cornhill & Case-Smith, 1996).

Spatial Recognition. According to Cornhill and Case-Smith kinesthesia is "awareness of weight of an object (and of a limb) and the directionality of joint and limb movement," meaning that one's sensory organs in each muscle and joint, or proprioceptors, make one aware of the movement and position of their limbs (1996). Kinesthesia works hand-in-hand with proprioception, which is the "joint position sense and awareness of joints at rest," whereas kinesthesia is during movement (Danzl &

Wiegand, pp. 140-149, 2017). Oftentimes, both kinesthesia and proprioception are referred to as spatial recognition. Sudsawad et al. (2002) used a sample of typically developing children with handwriting and kinesthetic dysfunction that implies that the two coexist. Spatial recognition influences the amount of pressure the child applies to their pencil and is needed to inform the child about the directionality of letters in order to form them. It has been theorized that spatial recognition is even more important than visual input in detecting movement error and guiding precise movements due to the immediate and highly specific information about movement that the somatosensory systems provide (Cornhill & Case-Smith, 1996). Overall, knowing the position of one's body in space intuitively appears related to handwriting performance.

Handwriting Without Tears Screener

Handwriting Without Tears in a handwriting program, however the screener can be used independently from the framework. The screener is a whole-class assessment intended to identify students who are struggling with handwriting (Figure 1). In a study determining the relationship between reading, writing, and math and the quality of handwriting, the *Handwriting Without Tears Screener of Handwriting Proficiency* showed a positive relationship with academic success, meaning higher scores on the screener were correlated with higher report card grades (McCarroll, & Fletcher, 2017). The screener provides objective data regarding the strengths and weaknesses of both individual students and classrooms as a whole. The *Handwriting Without Tears Screener of Handwriting Proficiency* provides four different grades, memory, orientation, sentence and placement, as well as a total score. This screener was chosen for its ability to be

given to the classroom as a whole, as well as its multiple score results to provide information about how prone position effects legibility.

Figure 1: The *Handwriting Without Tears Screener of Handwriting Proficiency*

The Effects of Prone

Prone positioning has been theorized to help handwriting difficulties and is even a common practice among occupational therapists. Through the "Prone to Play" campaign, the positive effects of prone on motor skills has been emphasized in infants since 2001, however, this emphasis on activities in prone position is currently not being carried out past infancy (Kuo, et. al., 2008). However, it has been theorized that studying

perceptual-motor body functions that underlie handwriting abilities may result in the development of programs for students with handwriting difficulties (Parush, et. al., 2010).

Prone position effects many of the underlying skills of handwriting. Handwriting "requires simultaneous cognitive, linguistic, perceptual and motor processing" (Grace, et. al., 2017). A study done in 2017 showed that "motor proficiency was significantly negatively correlated with difficulties learning to write" (Grace, et. al.). As previously discussed, motor skills are a result of core musculature providing proximal stability and distal mobility. Prone position has been shown to activate the core musculature that is necessary for handwriting (Escamilla, et. al, 2016). Not only do prone activities strengthen head, neck, and trunk muscles, but lying in prone also helps with spatial recognition. When laying in prone, one must use their elbows to prop them up, this results in the shoulder, arms and hands all receiving stimuli about the position and movement of their body and tactile input. The tactile input and stimuli help orient children to their position in space, improving their spatial recognition, another necessary skill for handwriting by (Parush, et al., 2010). Another important feature of prone that should be noted is its effect on wrist positioning. In order to use the elbows for stabilization, which is necessary in prone position, the wrist cannot be flexed during handwriting activities. This is influential on handwriting as the position of the wrist affects the length of finger muscles. In order to have the full range of motion necessary for handwriting the wrist cannot be flexed as this shortens the muscles, limiting range of motion (Yu & Chang, 2011). Wrist positionings influence on handwriting product quality and efficiency works hand in hand with the theorized idea that prone position effects handwriting legibility.

METHODS

The study was approved by the Eastern Kentucky University Institutional Review Board. All parents signed an informed consent; all participating teachers and children were asked for verbal assent.

Participants

Convenience sampling was used to identify the population of the study with the inclusion criteria of being between the ages of 5 to 7 and being enrolled in one of the two kindergarten classrooms being included in the study. Exclusion criteria included students who had been previously recommended to see the school's occupational therapist for additional educational performance problems. The parents of the children in both kindergarten classrooms were asked to give their informed consent in order to have their child participate in the study. The groups were determined by what class the child was in, meaning every student in one of the kindergarten classrooms was a part of the experimental or prone group (PG) and every student in the other classroom was a part of the comparison group with no added measures of intervention (CG). Based on parental consent, 22 participants were identified for the prone group and 21 participants for the control group. Kindergarten classrooms were used for the convenience sampling due to the emphasis of handwriting in kindergarten curriculum. A 2014 study found that kindergarten teachers dedicate at least one hour a day specifically to handwriting instruction (Puranik, et. al). Additionally, kindergartners spend nearly half their day engaged in fine motor activities, of which 42% was spent on paper and pencil tasks (Dinehart, 2015).

Research Design

A quantitative study using a quasi-experimental pre-posttest with a comparison group was conducted with the independent variable of lying in the prone position to write, while the dependent variable or the outcome of interest is handwriting legibility.

Setting

The study was conducted at public elementary school in Northern Indiana. The school serves 636 students Kindergarten through fifth grade. Of these students 59% of them scored at or above the level of proficiency for math, and 61% of these students scored at or above the level of proficiency for reading. The school also has a minority student enrollment rate of 16% and enrolls 33% economically disadvantaged students. There is a student-teacher ratio of 19:1 with 34 full-time teachers and 1 full-time school counselor. The student population is made up of 47% female students and 53% male students.

Procedure

After the participants were confirmed, both the experimental and control groups took a handwriting pretest, the Handwriting Without Tears Screener. The prone group's intervention began the following day and consisted of completing at least three handwriting activities while in the prone position every week for three weeks. In the control group participants completed the pre and posttest but did not complete any handwriting activities in prone, instead following standard classroom procedures for writing activities. Each participant was evaluated based on the differences of their scores in the pre and posttests, a screening of handwriting proficiency created by "Handwriting without Tears." Descriptive statistics are used to describe the population of participants in

the intervention and control group. Inferential statistics illustrate if there is a significant difference in handwriting legibility between the two groups. Statistical analysis of the data was completed to answer: Does lying in a prone position (on one's stomach using their elbows for stability) result in more legible handwriting?

Handwriting Without Tears. The Handwriting without tears screener provides four different scores: memory, orientation, placement, and sentence. The memory score rates the student's ability to remember and write dictated letters and numbers. The orientation score grades the student's ability to write letters and numbers facing the correct direction. The placement score grades the student's ability to place letters and numbers correctly on a base line. The sentence score grades the student's ability to use sentence conventions: a beginning capital, distinct lowercase words (letters close), space between words, and ending punctuation. The grading of the screeners includes taking points off for certain mistakes in each section. Memory errors include omitting the letter/number, writing an unrecognizable letter/number or writing the wrong letter/number (See Figure 2). No memory error is counted for a letter in the wrong place, such as letters like "P" and "Y" whose placement can affect their case, a letter that uses wrong size, such as "O", whose sizing can affect case, as well as a letter or number that is reversed. Orientation errors include reversals, or backward letters (Figure 3), however, no error is counted for symmetrical letters/numbers and letters that cannot be reversed are not scored, such as "A," "H," and "O." Placement scoring is based on errors for letter/number parts that should be on the line but are more than 1/8" above the line and letter/number parts that should be on the line but are more than 1/8" below the line (Figure 4). Sentence errors are counted for not using a capital to begin (Figure 5.1),

mixing capital and lowercase letters (Figure 5.2), putting too much space between letters in a word (Figure 5.3), putting words too close (Figure 5.4) and/or forgetting ending punctuation (Figure 5.5).

Figure 2: Memory Errors

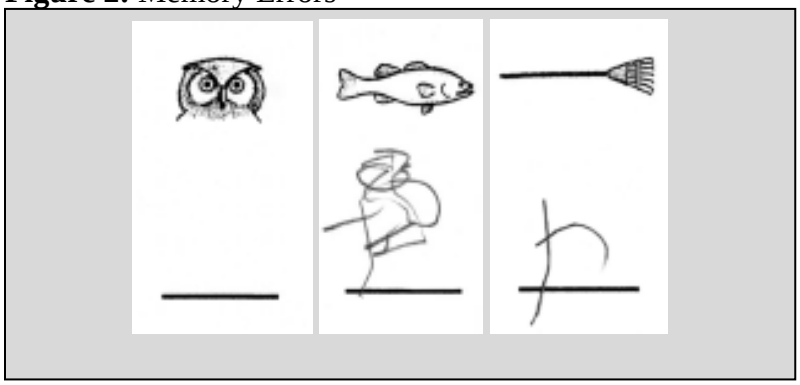


Figure 3: Orientation Errors

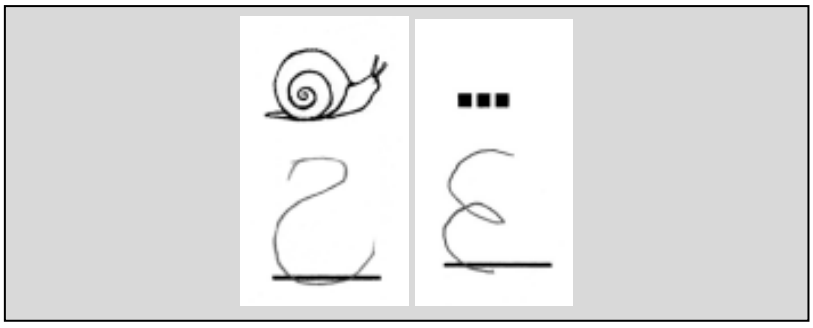


Figure 4: Placement Errors

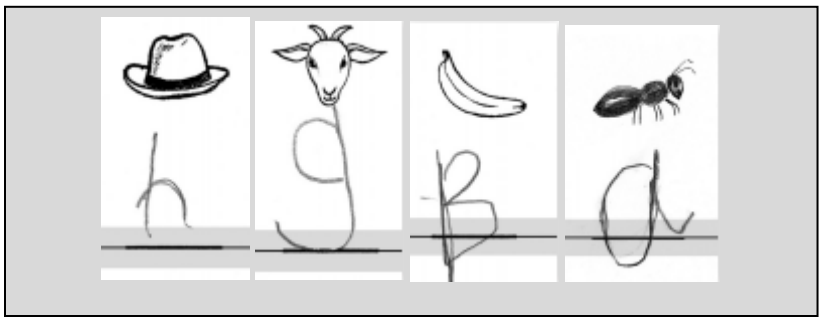
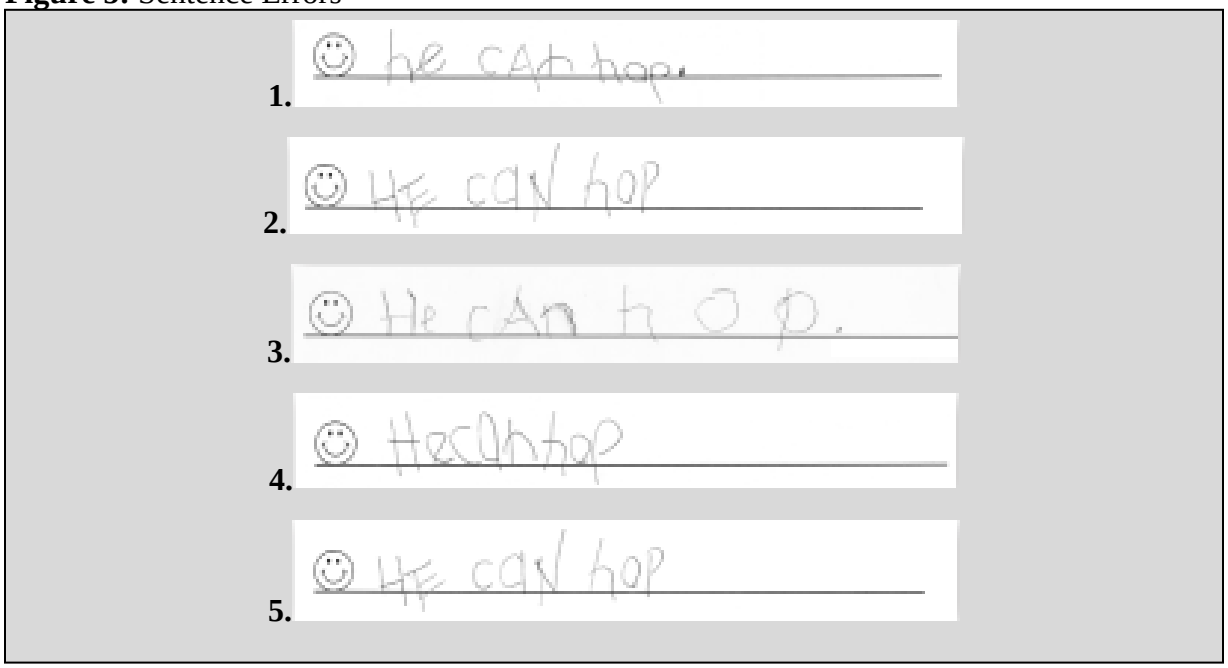


Figure 5: Sentence Errors



DATA ANALYSIS

The level of significance was set a priory at p is less than .05, meaning the disoriented chance is less than 5%. Jamovi was used to conduct a variety of tests. Pre-post paired t-Tests of both groups were conducted to display if there was a significant difference between the pre and posttest scores as a measure of the student's progress. A control versus prone pre-post difference paired t-Test was conducted in order to see if there was a significant change in the prone groups score differences over the control group. To summarize the data set descriptive statistics were used. Measures of central tendency were analyzed, including mean, median to describe the center of a data set. Measures of variability to describe the dispersion of data within the study through standard deviation.

RESULTS

Table 1: Descriptive Statistics-Prone Group

	Pre Mem	Pre Ori.	Pre Place.	Pre Sent.	Pre Total	Post Mem.	Post Ori.	Post Place.	Post Sent.	Post Total
N	22	22	22	22	22	22	22	22	22	22
Missing	0	0	0	0	0	0	0	0	0	0
Mean	91.5	89.6	79.6	63.6	81.2	98.3	94.2	91.9	100	96.2
Median	94	95	83	60	82.5	100	100	91	100	97
Std.Dev.	10.7	12.8	15.2	25.9	13.0	4.55	9.61	8.29	0.00	4.43
Min	63	61	35	0	58	83	67	75	100	86
Max	100	100	100	100	100	100	100	100	100	100

Table 2: Descriptive Statistics-Control Group

	Pre Mem	Pre Ori.	Pre Place.	Pre Sent.	Pre Total	Post Mem.	Post Ori.	Post Place.	Post Sent.	Post Total
N	21	21	21	21	21	21	21	21	21	21
Missing	0	0	0	0	0	0	0	0	0	0
Mean	89.0	92.1	72.7	74.3	82.0	93.7	91.4	68.0	81.0	83.7
Median	92	94	79	80	86	96	95	73	80	86
Std.Dev.	12.8	7.97	16.9	19.1	10.4	7.69	8.98	16.7	22.3	10.0
Min	50	69	29	20	58	79	75	35	20	61
Max	100	100	95	100	95	100	100	96	100	96

Descriptive

Descriptive statistics are used to describe the population of participants in the intervention and control group. Descriptive statistics can be seen in tables 1 and 2, the N depicted on these tables refers to the number scores used to calculate the following data, which is 22 for the prone group and 21 for the control group, these values are also equal to the number of participants for each group. To model the data set the mean is analyzed for both groups as well as both sets of test scores as it is the most common value, producing the lowest amount of error compared to the other values in the data set. The mean varies widely between each different set of scores but can be seen in tables 1 and 2. As the number directly in the middle of the data set, the median separates the upper and lower halves of the data, ranging from 60% to 100% in all sets of data. Standard deviation is used to describe how the values of the data sets are spread out from the mean. See table 2 to view standard deviations for each score of the control group and table 1 for the same data the prone group. The value of highest frequency, the maximum, can be seen in table 1 as 100% for all data in the prone group, however, in the control group it varies from 95% to 100%, as seen in table 2. These tables also show the minimum, the value of lowest frequency, with the lowest minimum in the data set being zero and the highest minimum being 100%.

Table 3: Control vs. Prone Pre-Post Difference Paired t-Test

Control	Prone		statistic	df	p
Memory Diff	Memory Diff	Student's t	0.923	20.0	0.367
Orientation Diff	Orientation Diff	Student's t	1.983	20.0	0.061
Placement Diff	Placement Diff	Student's t	3.804	20.0	0.001
Sentence Diff	Sentence Diff	Student's t	3.991	20.0	< .001
Total Diff	Total Diff	Student's t	5.899	20.0	< .001

Table 4: Control Pre-Post Paired t-Test

Pre	Post		statistic	df	p
Memory	Memory	Student's t	2.265	20.0	0.035
Orientation	Orientation	Student's t	-0.493	20.0	0.628
Placement	Placement	Student's t	-1.532	20.0	0.141
Sentence	Sentence	Student's t	1.673	20.0	0.110
Total Diff	Total Diff	Student's t	1.246	20.0	0.227

Table 5 : Prone Pre-Post Paired t-Test

Pre	Post		statistic	df	p
Memory	Memory	Student's t	3.52	21.0	0.002
Orientation	Orientation	Student's t	1.85	21.0	0.078
Placement	Placement	Student's t	5.44	21.0	< .001
Sentence	Sentence	Student's t	6.58	21.0	< .001
Total Diff	Total Diff	Student's t	7.09	21.0	< .001

Figure 6: Performance Distribution Chart Key

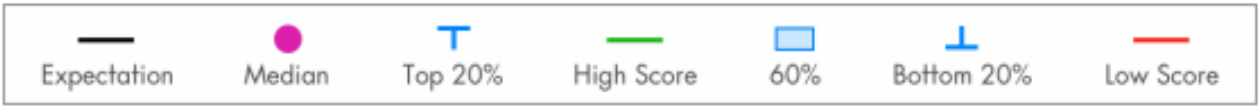


Figure 7: Prone Pre-Test Performance Distribution Chart

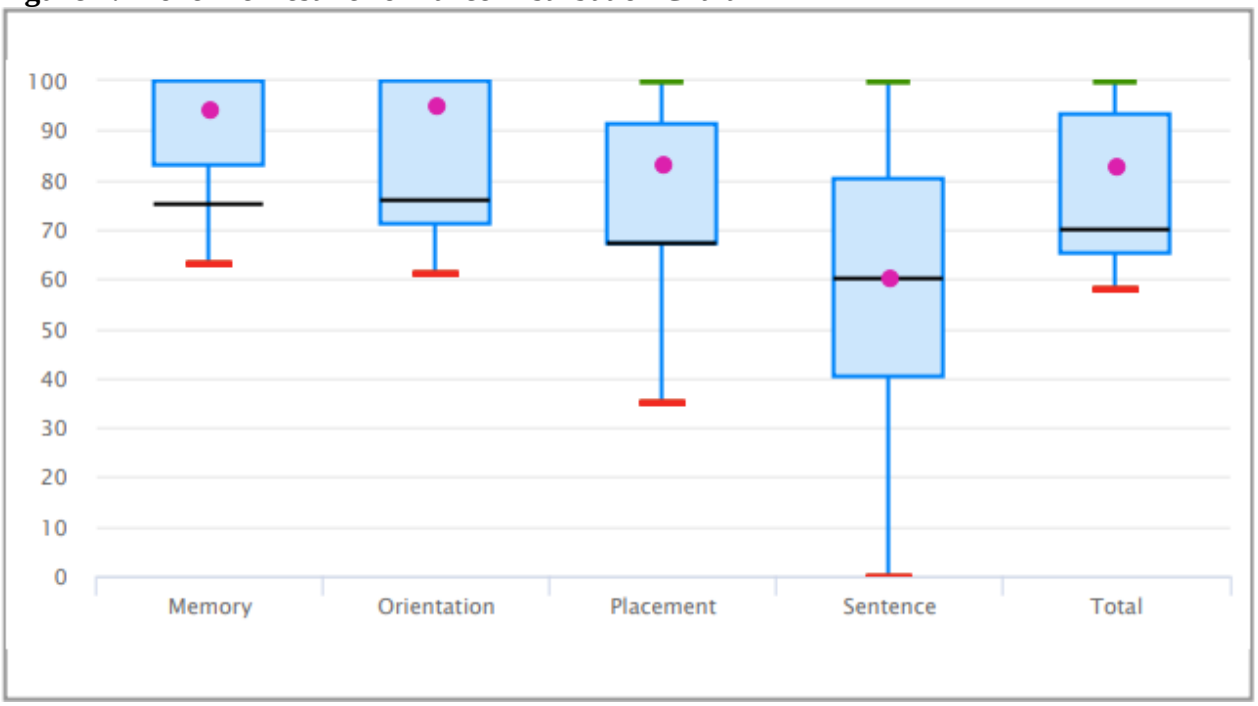


Figure 8: Prone Posttest Performance Distribution Chart

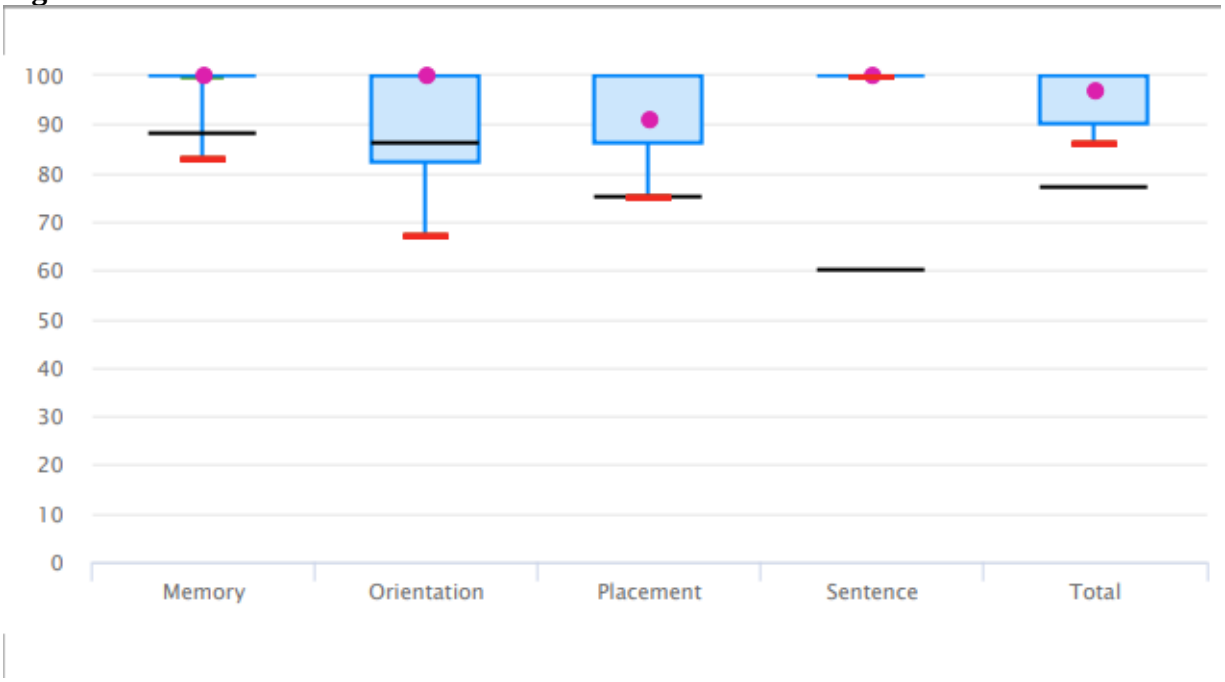


Figure 9: Control Pre Test Performance Distribution Chart

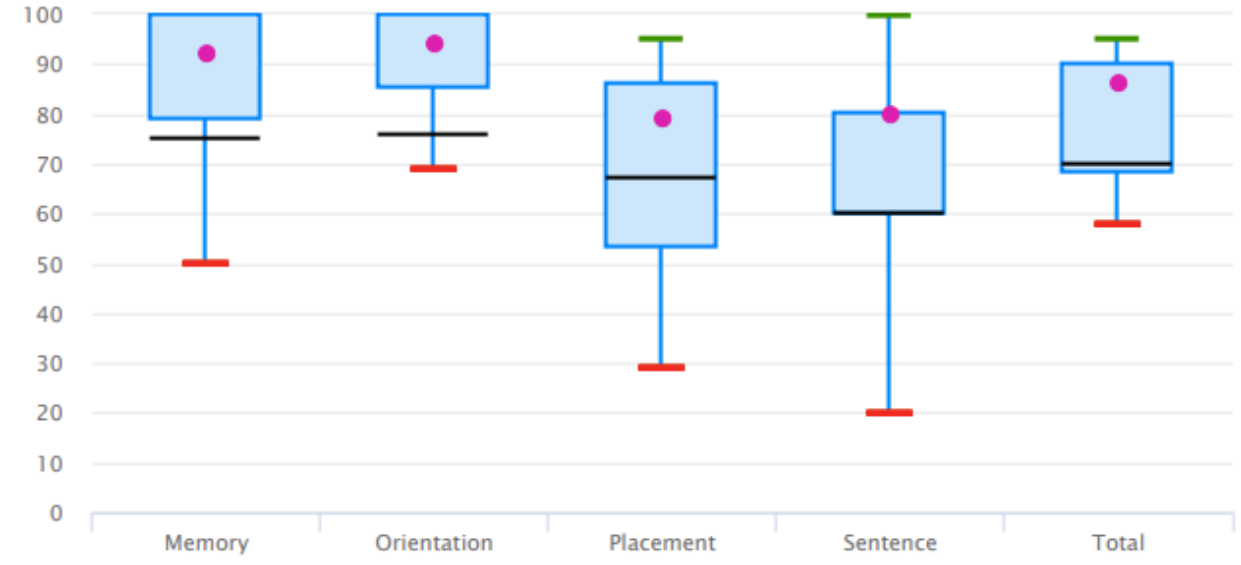
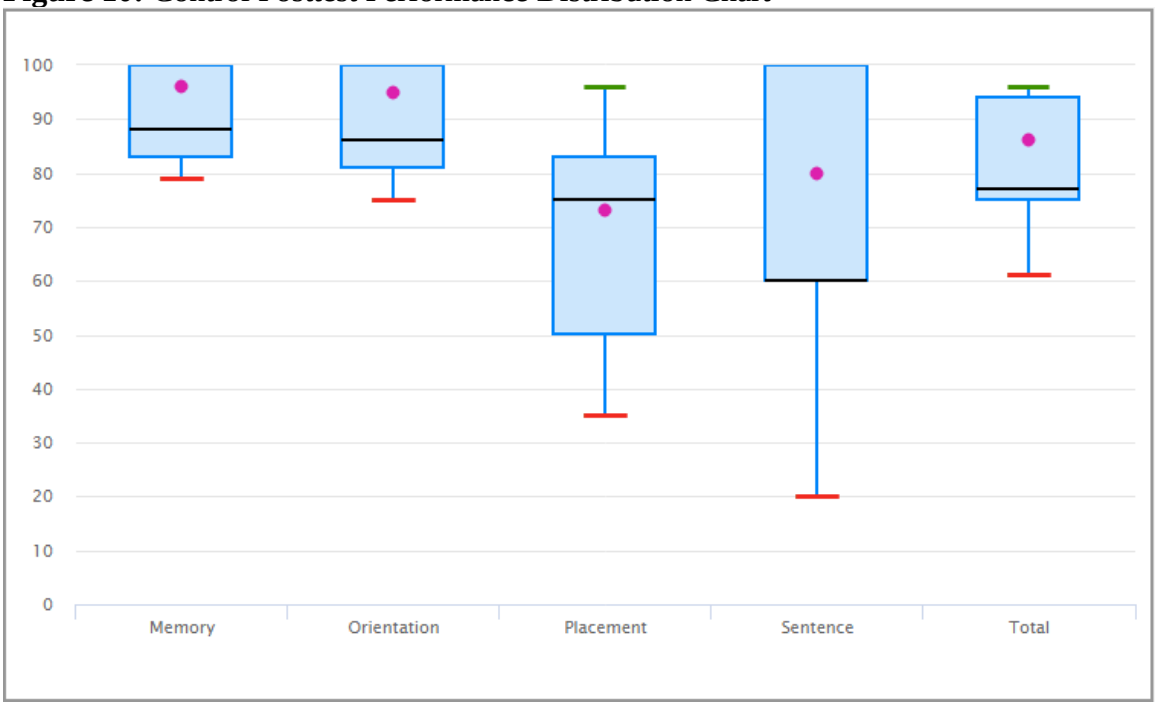


Figure 10: Control Posttest Performance Distribution Chart



Quantitative

In the pre-post paired t-tests, memory showed significant improvement for the control and the prone groups, however, the control group had a decrease in orientation and placement (Table 4). Table 5 shows the pre-post paired test of the prone group displaying how the prone group's placement, sentence and total scores all increased by a significant level of p less than 0.001. In the differences between the groups in terms of memory and orientation there was not a significant difference between the two groups, which can be seen in table 3. However, table 3 also shows that the placement, sentence skills and total test score differences all show that the prone group had an improvement over the control group.

Through the Handwriting Without Tears website data summarizing the range and performance of the participants was obtained. This data is displayed through performance distribution charts for both the pre and posttest of each group. This measurement shows

how the students are writing in comparison to the expectations they should be achieving as kindergarteners. To read these performance distribution charts refer to figure 6 which displays a key to what each value is depicted by. The expected goals are based on the beginning, middle or end of the school year. Due to the time period of the study beginning in March and ending in late April, pretest scores were evaluated based on mid-year expectations, while post-tests were compared to end of year expectations. The expected total score for kindergarteners on the pretest is 70%. The expected pretest scores for each category of the screener varies, expecting students to earn a 75% for memory, 76% for orientation, 67% for placement and 60% for sentence. Reference figure 7 to see how on the pretest the prone group had 77% of the participants are at or above total score expectation while 23% are below. On this same figure the memory, placement, orientation, and sentence scores can be seen against their expectation, showing that 86% of prone participants reached the expectation for memory, 82% did the same for orientation, 91% in placement scores and 68% of students in the prone group met the expectation for sentence score. Based on the same expectation goals, the control pretest scores were displayed, which can be seen in figure 9. Of the control group participants total pretest scores 81% of them met the expectation. For other scores, 90% were at or above expectation for memory, 62% for placement score, and 95% for both orientation and sentence scores.

The posttests scores were set at an expectation rate of an overall score of 77%. Rates for the other scores included 88% for memory, 86% for orientation, 75% for placement and 60% for the sentence score. For the prone group's posttest 100% of the students met the expectation rate for total score. See figure 7 to review how in terms of

other scores from the screener, of the prone posttests participants 95% of students met the expectation for memory, 82% for orientation, and 100% of the students met the expectation. In the control group posttest scores, displayed in figure 10, 71% of the students are at or above expectation for total scores. Again, in figure 10, it can be seen how 81% of students met the expectation for memory, 71% for orientation, 43% for placement and 90% for sentence score.

The participants scores can also be seen through individual skill reports for each test. These individual reports break down the scores by student, displaying the expected total score with a black line, and the median with a pink dotted line, all of which can be seen in the individual skill reports key, figure 11. For prone scores one can see how five students did not meet expectation for pretest in figure 12 and in figure 13 it is very clear the for the prone protest every student met the expected total score. These figures can be compared to their control group counter parts. In figure 14 it is shown that only four students did not meet the expectation for the pretest total scores, however, it can be seen how these students did not necessarily progress as well as the prone group on the posttest which had a slightly elevated expected score in figure 15 which shows that six students did not meet the expected goal for the posttest.

Figure 11: Individual Skill Report Key

Figure 12: Prone Pre-Test Individual Skill Report

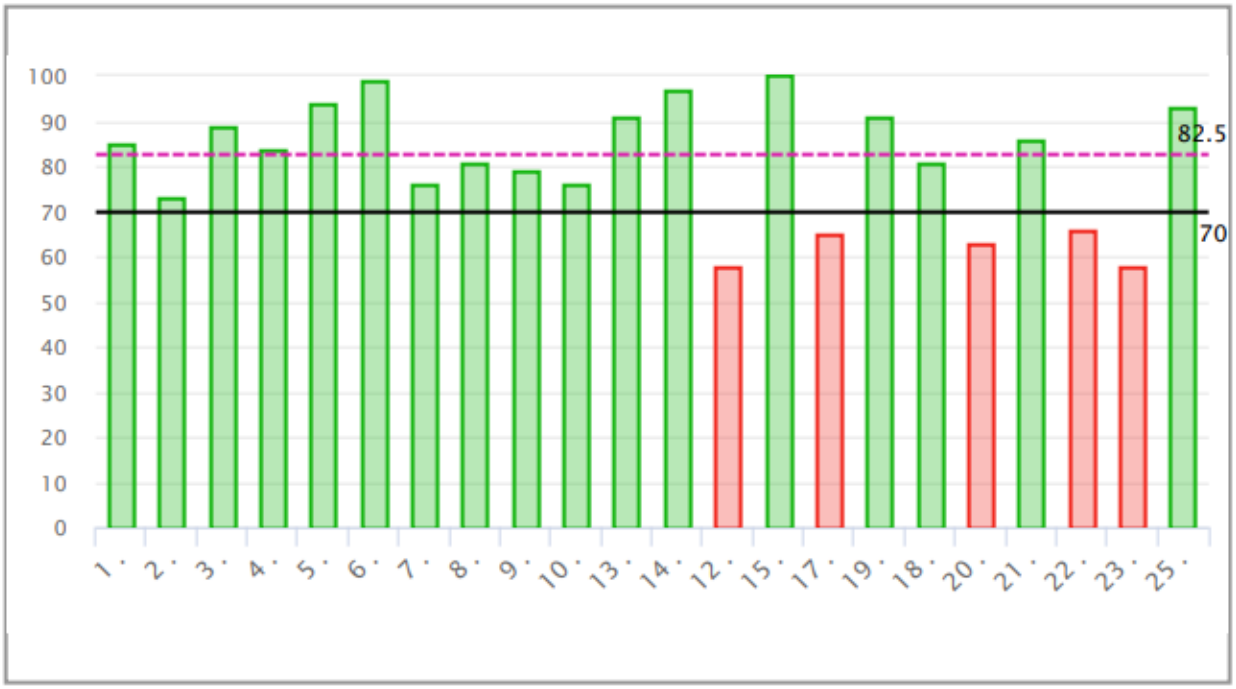


Figure 13: Prone Posttest Individual Skill Report

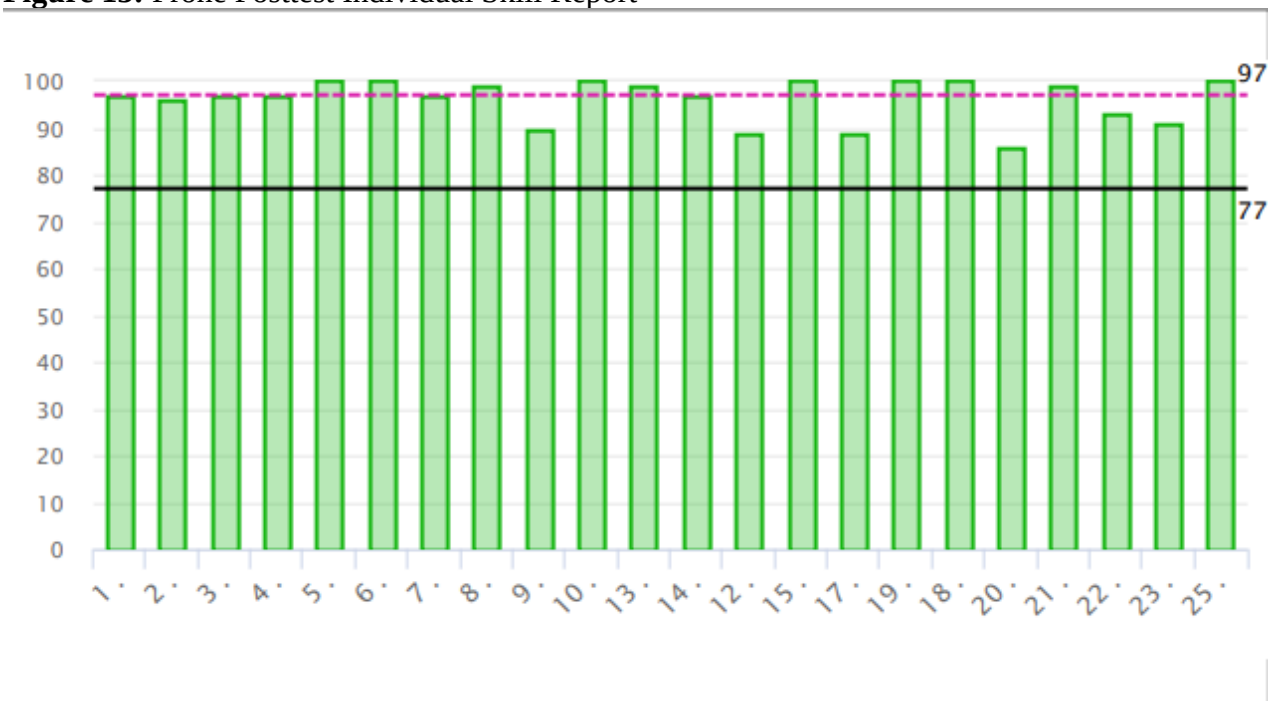


Figure 14: Control Pre-Test Individual Skill Report

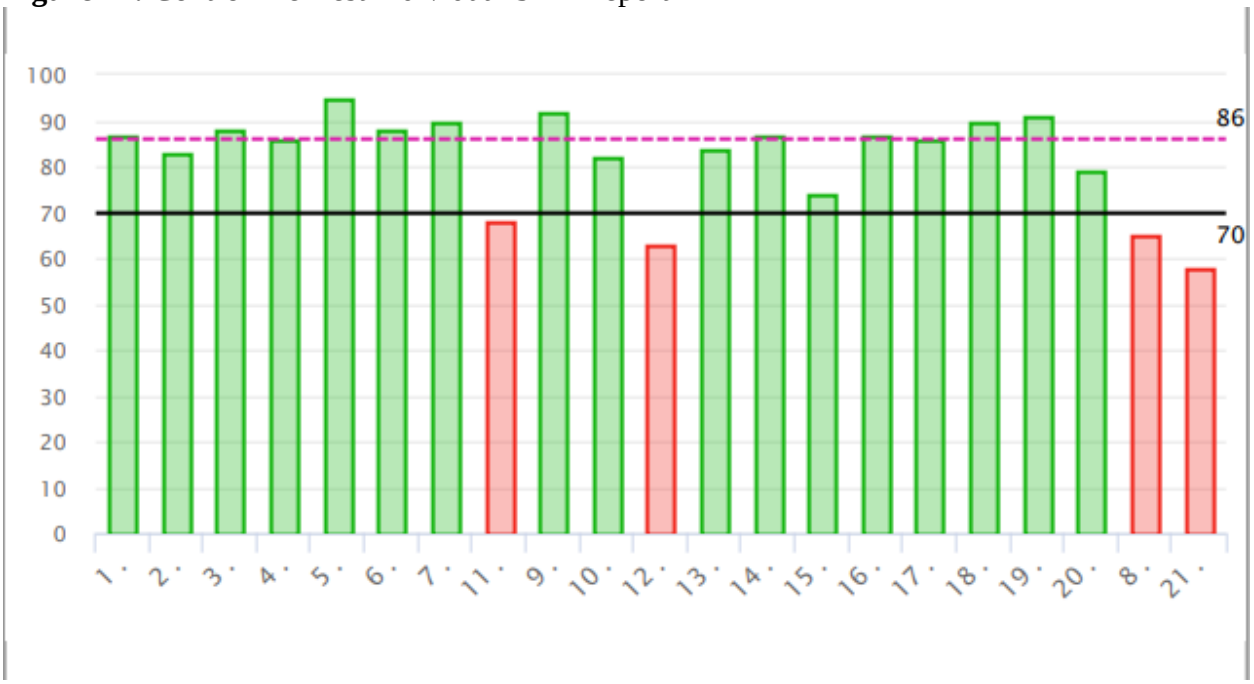
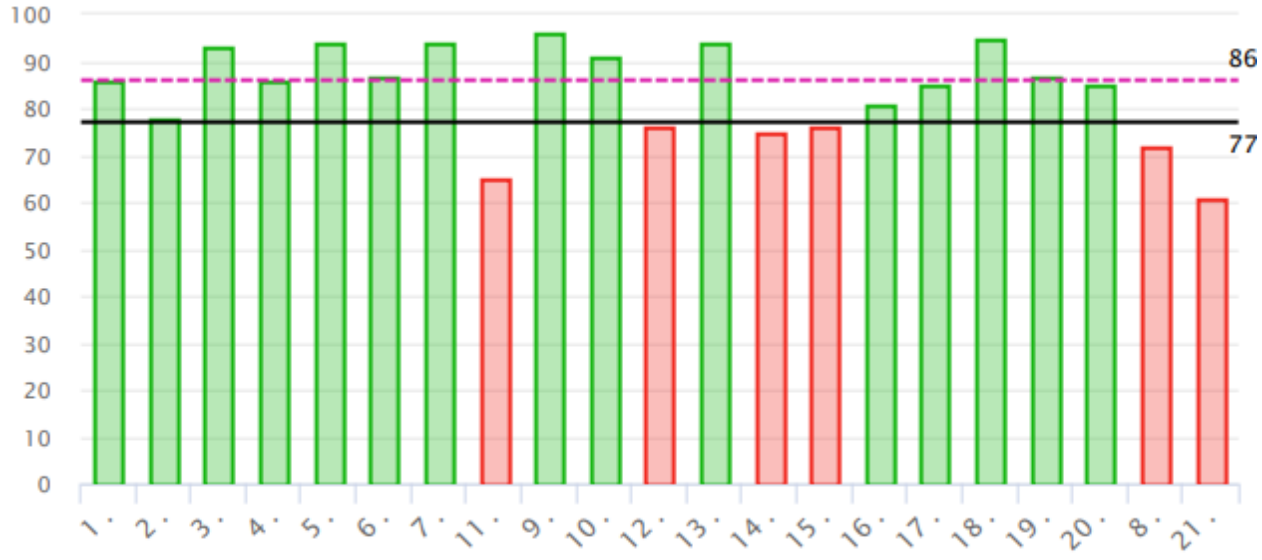


Figure 15: Control Posttest Individual Skill Report



Qualitative

Some qualitative results of the study were found at the end of the intervention period through discussion with the instructor for the prone group. This teacher discussed how much the participants enjoyed writing in prone. She noted how they viewed writing in prone as a fun activity, and after a few sessions began to ask if they could do their work on the floor after being handed a worksheet. She discussed the school's use of "brain breaks" periods of time during the day in which they would play a YouTube video or listen to a song and students were encouraged to get out of their seats and move around. She related writing in prone to "brain breaks" in the fact that the students not only enjoyed them but resulted in her students having better focus as a result of not having to stay at their seats. After learning how her students performed better on the posttests the teacher proclaimed that she would be continuing to have her students write in prone not only because of the positive results found in the study, but the positive effects she noticed in her students' attitudes as a result from doing activities in prone.

FINDINGS AND DISCUSSION

The study found that for the twenty-two kindergarteners that completed handwriting activities in the prone position their handwriting legibility increased in comparison to their counterparts who did not complete any activities in prone. The results from this study are relevant to the understanding of the handwriting components effected by writing in prone position.

Limitations

Despite the conclusions displaying the positive influence of prone on handwriting legibility, this study cannot be generalized due to its limitations. It must be noted that the intervention period was only three weeks, making it relatively short for generalization purposes. The use of convenience sampling also hinders the study's generalization, as well as the participant's having different levels of abilities with most not having handwriting difficulties. Another limitation presents itself in the evaluations, which were not norm referenced.

Further Research Implications

In order to generalize the findings of the study, further research must be done. To address the limitations in the study population, research should be conducted using random sampling. These studies should also include a larger number of study participants in various age groups. A study in which groups are decided by level of ability is also recommended. The limitations of the intervention of the study should be used to modify further research so that it includes a longer intervention period, prone activities daily and an emphasis on participants having a consistent pencil grip. It is also suggested that there be further research on the effects of lying in prone on handwriting using different evaluations, such as using various evaluations and evaluations that specifically focus on legibility.

An unforeseen result of the study could also use further inquiry. Based on the prone group's teachers' positive reviews of how writing in prone effected the attitudes and level of focus of her students as well as legibility, the study calls for further research

into how movement and alterations from the seated position for writing could be beneficial.

CONCLUSION

Despite the results of the study inability to be generalized, they are still particularly important as they address the current lack in research surrounding the effects of lying in prone on handwriting legibility. Prone activities are currently a common intervention occupational therapists use for students with handwriting difficulties; however, little evidence backs this intervention. There is ample research displaying the positive effects of prone or “tummy time” for infants’ development, however, through further research this emphasis on prone activities could be extended to show the importance of lying prone much past infancy. The multifaceted activity of lying prone could be beneficial for a variety of reasons, and upon further research may become a common classroom activity.

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